Dissertation on

BINOCULAR SINGLE VISION ACHIEVED FOLLOWING SURGICAL CORRECTION OF LONG STANDING STRABISMUS AFTER 2 YEARS OF AGE

Submitted in partial fulfillment of requirements of

M.S. OPHTHALMOLOGY

BRANCH – III

REGIONAL INSTITUTE OF OPHTHALMOLOGY

MADRAS MEDICAL COLLEGE

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CHENNAI

APRIL 2016

CERTIFICATE

This is to certify that this dissertation entitled "**BINOCULAR SINGLE VISION ACHIEVED FOLLOWING SURGICAL CORRECTION OF LONG STANDING STRABISMUS AFTER 2 YEARS OF AGE**" is a bonafide record of the research work done by **DR. PRASANNA.V**, post graduate in Regional Institute of Ophthalmology and Government Ophthalmic Hospital, Madras Medical College and Government General Hospital, Chennai-03, in partial fulfillment of the regulations laid down by the The Tamil Nadu Dr. M.G.R. Medical University for the award of M.S. Ophthalmology Branch III, under my guidance and supervision during the academic years 2013-2016.

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DECLARATION BY THE CANDIDATE

I hereby declare this dissertation entitled “Binocular single vision achieved following surgical correction of long standing strabismus after 2 years of age” is a bonafide and genuine research work carried out by me under the guidance of Prof. Dr.M. Ananda Babu. M.S D.O.,

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PART I

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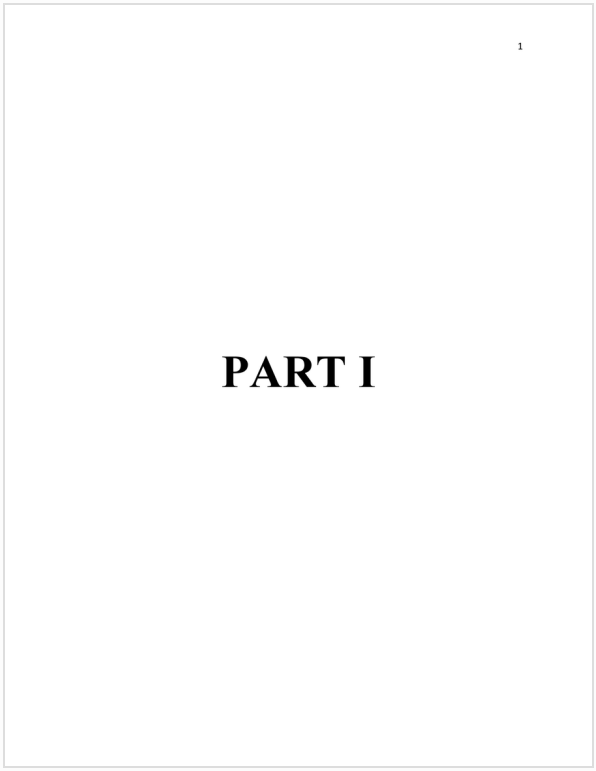

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Dear Dr.V.Prasanna,

The Institutional Ethics Committee has considered your request and approved your study titled **"Binocular single vision achieved following surgical correction of long standing strabismus after 2 years of age" No.13062015.**

The following members of Ethics Committee were present in the meeting held on 09.06.2015 conducted at Madras Medical College, Chennai-3.

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12. Thiru S.Govindasamy, B.A., B.L.,	: Lawyer
13. Tmt.Arnold Saulina, M.A., MSW.,	: Social Scientist

We approve the proposal to be conducted in its presented form.

The Institutional Ethics Committee expects to be informed about the progress of the study and SAE occurring in the course of the study, any changes in the protocol and patients information/informed consent and asks to be provided a copy of the final report.

Member Secretary, Ethics Committee

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PART I

INTRODUCTION

BINOCULAR SINGLE VISION:

It is a state of simultaneous vision with the coordinated use of both eyes, wherein blending of sight from both eyes occur, leading to a single image percept. The normal binocular single vision is an integrated function of both the fovea. Hence there is orthophoria. It becomes abnormal if for eg, image of an object projects to fovea of right eye and extrafoveal point of the left eye.

DEVELOPMENT:

There are several theories [1] postulating the development of binocular single vision, like

1. Theory of correspondence and disparity
2. Theory of isomorphism
3. Theory of projection
4. Alternation theory of binocular vision
5. Neurophysiologic theory of binocular vision and stereopsis.

The most accepted theory is the theory of correspondence and disparity. The postulates are

1. Corresponding elements of retina form the frame work of zero system of binocular vision.
2. Simultaneous stimulation of the corresponding points by one object transmits single visual impression with no depth quality.

3. Simultaneous stimulation by two objects points that difference in character results in binocular rivalry.
4. Diplopia occurs when disparate elements are stimulated by one object.
5. Binocular single vision with stereopsis results when the horizontal disparity remains within the limits of panum's area.

MILESTONES IN NORMAL BSV DEVELOPMENT:

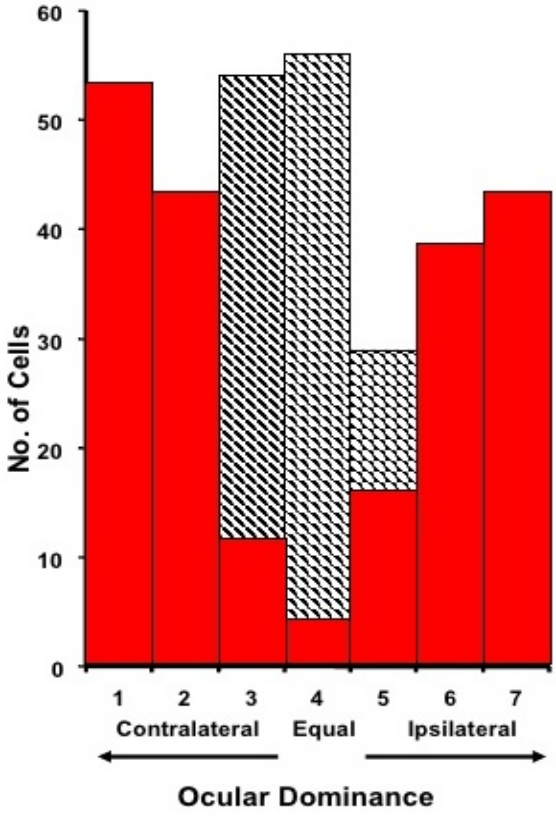
- ✓ At Birth – Exotropia.

  Irregular Fixation, Alignments continue till 2 mths
- ✓ Fixation Reflex – 4 to 5 weeks
- ✓ Refixation Reflex – 6 To 8 Weeks
- ✓ Fixation In All Gazes – 3 months
- ✓ Stereopsis – 3 to 6months
- ✓ Gradual improvement in stereoacuity till 6 to 9 Yrs
- ✓ Binocular Vision develops by 3 to 4 months, reaches a peak at 2 years, well developed by 4 yrs continues till 9 yrs
- ✓ 6 Months, Adduction is present with 8 PD BO Prism

NEUROPHYSIOLOGAL BASIS FOR BINOCULAR VISION:

Stereopsis is said to be coded by the neurons in V1 area of the visual cortex. Till this level, the visual information from each eye remains separate and

segregated. Binocular neurons in this area receive input from both eyes and produce stereopsis. This concept of binocularity of neurons was given by Hubel and Wiesel[2].



Ocular dominance distribution of 233 cells from the striate cortex of the cat. Each cell is assigned to an ocular dominance group 1-7 according to the relative response weighting from the two eyes.

(Wiesel & Hubel 1963)

Fig.1. Ocular dominance columns in cortex

Binocular neurons may act as disparity sensors and are responsive to stimuli at specific distances.

LEVELS OF BINOCULAR SINGLE VISION

LEVELS:

Worth[3] classifies BSV into 3 grades, namely

Grade 1: simultaneous macular perception

Grade 2: fusion

Grade 3: stereopsis

SIMULTANEOUS MACULAR PERCEPTION:

Simultaneous perception exists when signals transmitted from the two eyes to the visual cortex are perceived at the same time. In essence it is the power to see two dissimilar objects simultaneously.

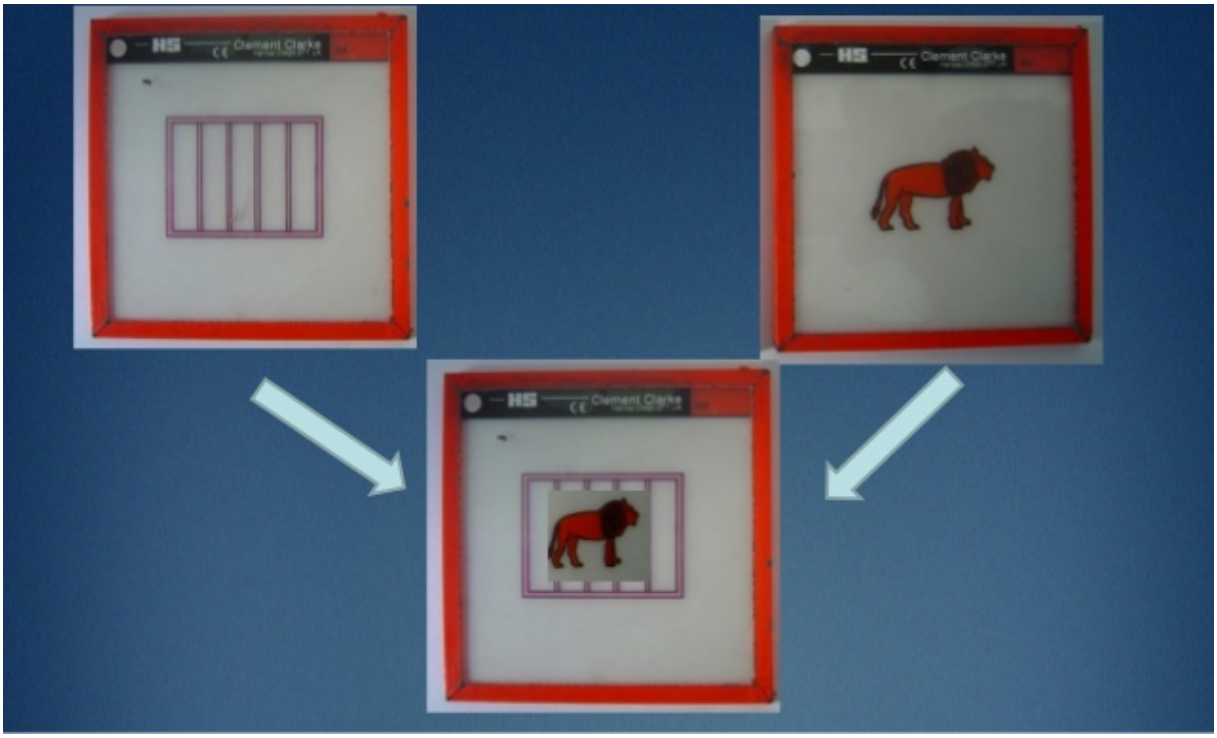


Fig.2. Slides for testing simultaneous macular perception

FUSION:

It is the cortical unification of 2 visual objects into single percept, each of which is incomplete in one small detail.

SENSORY FUSION:

- It is the ability to appreciate two similar images, one with each eye and interpret them as one.
- For sensory fusion to occur, the images not only must be located on corresponding retinal areas but also must be sufficiently similar in size, brightness and sharpness.

Testing Distance	Convergence Fusional Amplitude	Divergence Fusional Amplitude	Vertical Amplitude
6 m	14	6	2.5
25 cm	38	16	2.6

Table 1.Range of convergence and divergence fusion

MOTOR FUSION:

- ✓ It is the ability to align the eyes in such a manner that sensory fusion can be maintained.
- ✓ Stimulus is the retinal disparity outside panum's area and the eyes moving in opposite direction (vergence).
- ✓ Predominantly a function of the extrafoveal peripheral points of retina.

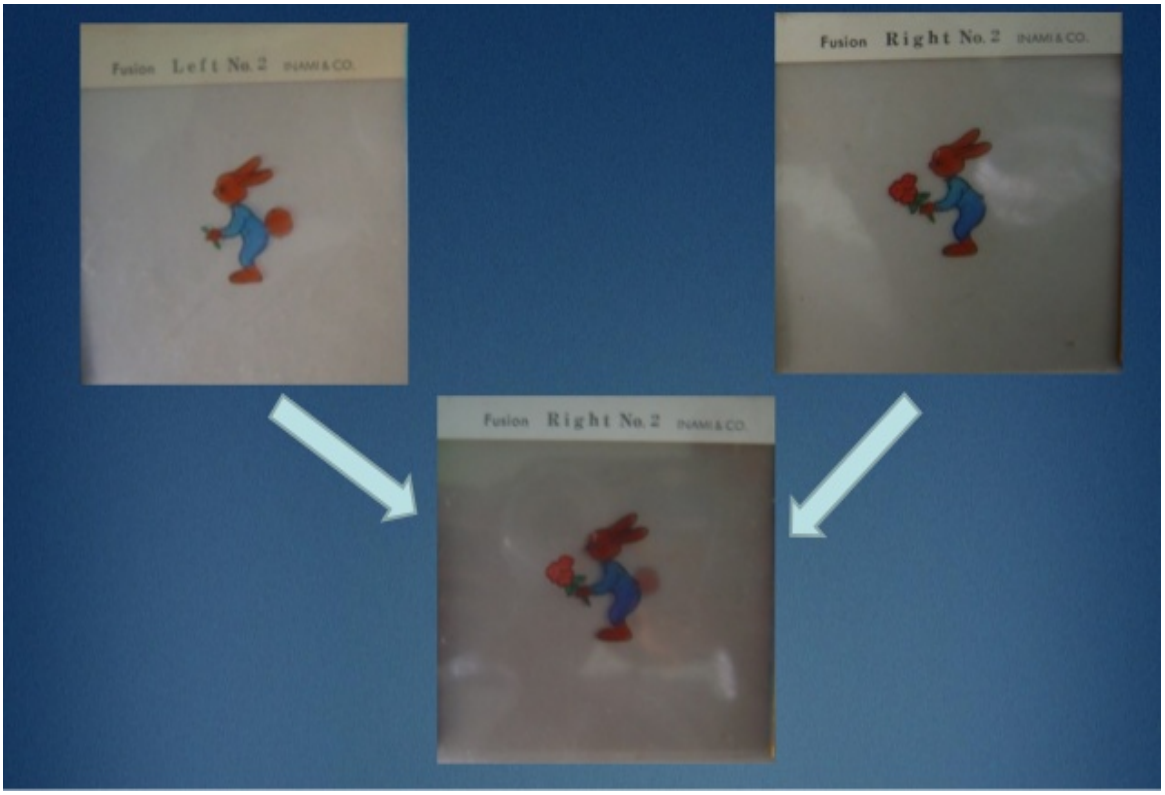


Fig3. Slides for testing fusion

STEREOPSIS:

It is the ability to perceive relative distances of objects from the observer. It is due to horizontal retinal image disparity. Vertical image disparity does not produce stereopsis. For this 3 D phenomenon to occur, images must be within the pannums space. There are two types:

1. Contour stereopsis
2. Random Dot stereopsis

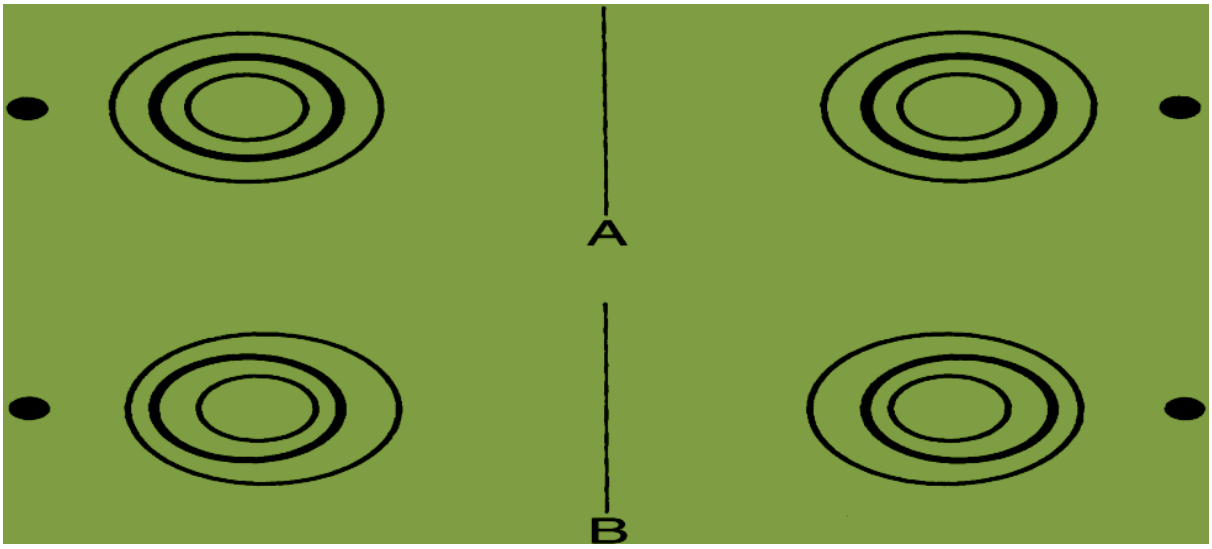


Fig4. Slides for testing stereopsis

MONOCULAR CUES:

These are non-stereo depth cues[4]. Patients with binocular single vision defect can still perceive some depth due to these cues.

- Motion Parallax
- Linear Perspective
- Contour overlay
- Size
- Distance From Fixation
- Distribution Of Highlights, Shadows, Shades And Light
- Aerial Perspective

CENTRAL AND PERIPHERAL BINOCULAR VISION:

Central BSV is when the cortex recognizes the images on macula and integrates it. It is more important than peripheral BSV. Peripheral BSV is extra-macular function, important for the subconscious orientation of the surrounding.

	Central BSV	Peripheral BSV
Simultaneous Perception	None	Excellent
Fusion	Limited	Excellent
Stereopsis	Excellent	Limited

Table 2.Comparison between Central and Peripheral BSV

PRE REQUISITES FOR A NORMAL BINOCULAR SINGLE VISION:

- Clear and equal optical apparatus in both eyes[5]
- Intact fixational and fusional reflexes
- Overlapping visual fields
- Proper extraocular co-ordination
- Ability of cortex to promote binocular fusion.

So, essentially the anatomical, motor and sensory systems should be normal for binocular single vision to occur.

ADVANTAGES OF BINOCULAR SINGLE VISION:

1. Stereopsis
2. Binocular vision, hence vision is clearer, sharper and more sensitive
3. Larger field of view
4. Compensates for blind spot of each eye
5. Optical defects in one eye made less conspicuous by the normal image of the other eye

Animals preyed upon:

-- Gain from 360 field of view, with eyes pointing in opposite directions

Predators:

-- Gain from eyes facing in same direction. Hence predators including humans evolved by developing organisation such as

- Frontally placed eyes (for overlap of visual field)
- Binocular coordination of eye movements wherein objects stimulate corresponding points. (muscles yoked together)
- Semi decussation of optic tract (interaction of inputs from different parts of retina)
- eye hand coordination

CONCEPT OF HOROPTER AND PANUM'S AREA

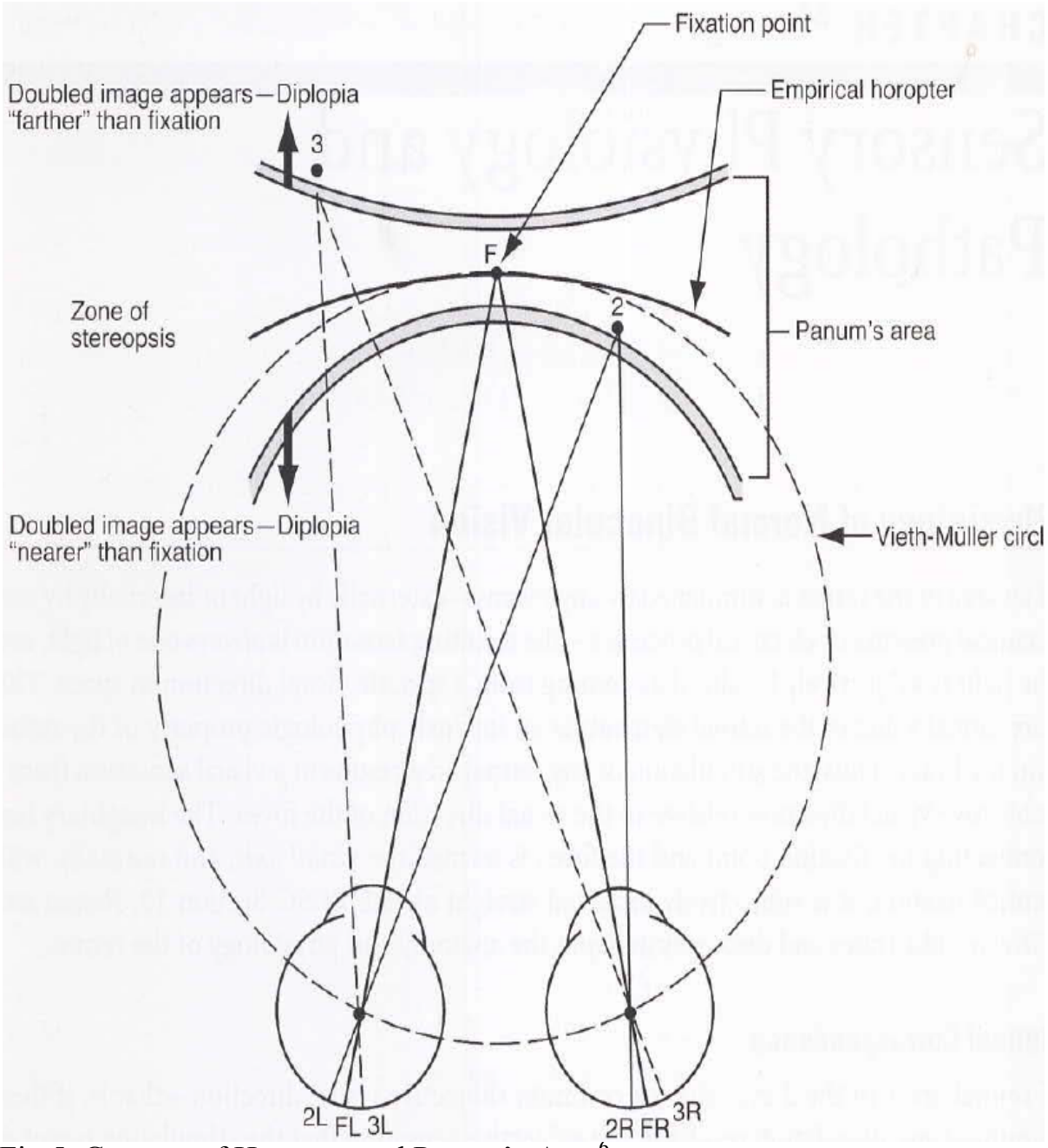


Fig.5. Concept of Horopter and Panum's Area[6]

- HOROPTER
- PANUMS AREA
- PHYSIOLOGICAL DIPLOPIA

HOROPTER:

It is simply the horizon of vision, the locus of all points which stimulate the corresponding retinal elements and are seen as a single image. Object points lying on this horopter are seen single, away from this are seen double.

PANUM'S AREA:

It is the narrow imaginary band traversing the horopter, where in points though slightly off from horopter can still give rise to binocular single vision. Objects here stimulate slightly non corresponding points[7].

PHYSIOLOGICAL DIPLOPIA:

It is elicited by object points outside pannum's fusional space. It can be crossed (heteronymous) or uncrossed (homonymous)[8].

In short, objects on the horopter will stimulate the corresponding points. Objects within the panums area produce retinal disparity and signal depth. Objects outside panums area produce diplopia.

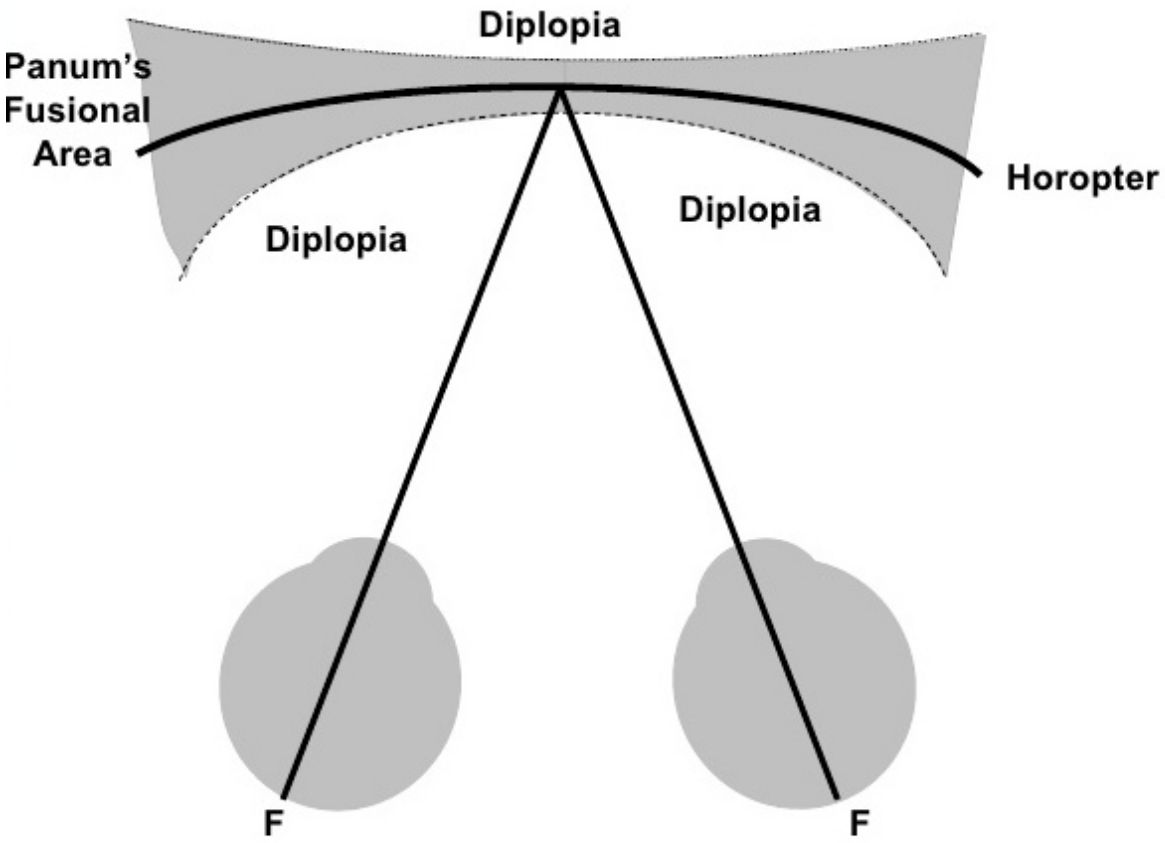


Fig 6.Picture showing Panum's fusional space beyond which diplopia occurs.

ADAPTATION MECHANISMS:

MOTOR:

1. FUSION : beyond fusional reserve – asthenopia develops
2. ABNORMAL HEAD POSTURE

SENSORY:

1. DIPLOPIA
2. CONFUSION
3. SUPPRESSION
4. ECCENTRIC FIXATION
5. ANOMALOUS RETINAL CORRESPONDENCE
6. AMBLYOPIA

DIPLOPIA:

This occurs due to the malalignment of the visual axis, wherein for eg, fovea of right eye and extrafovea of left eye become corresponding points.

It can be crossed or uncrossed. Diplopia is absent in congenital squints[9].

CONFUSION:

This occurs when different objects stimulate the primary corresponding points, i.e., the two foveae. They are therefore seen in same visual direction creating overlap[10].

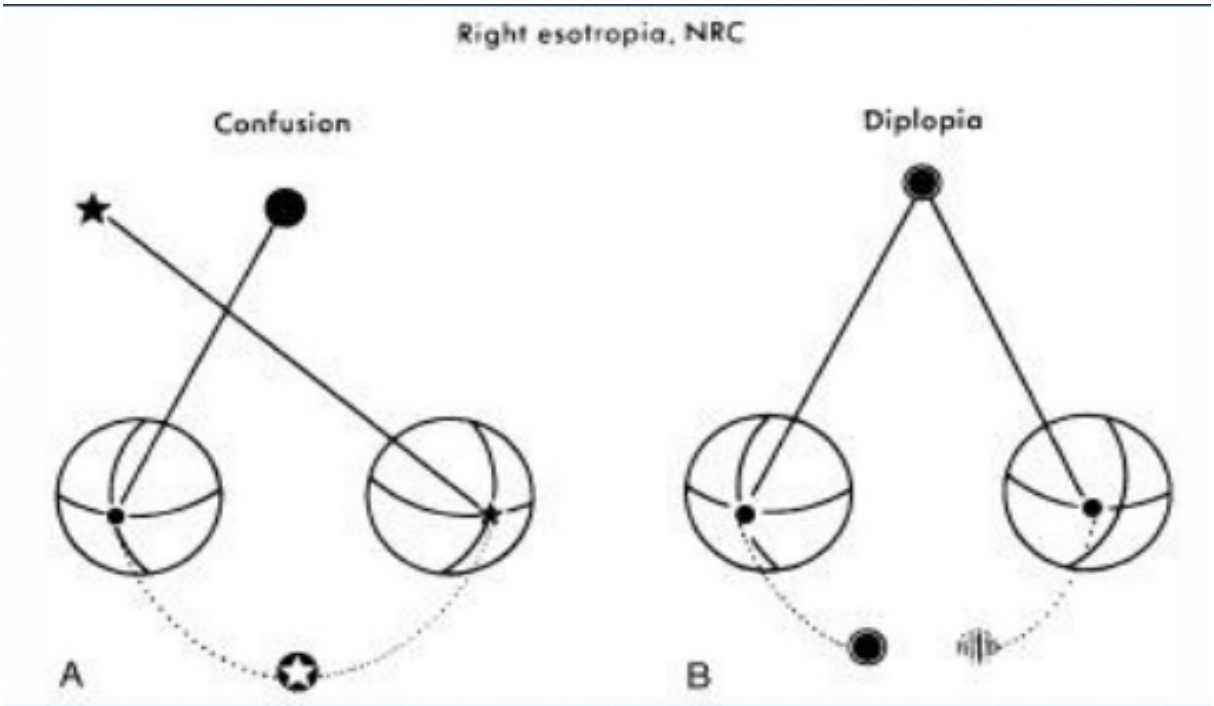


Fig 7.Pictorial representation of confusion and diplopia.

SUPPRESSION:

It is an active inhibitory cortical mechanism which occurs when the binocular single vision is disturbed. It can be facultative or obligatory. If suppression becomes active, there is no confusion/diplopia and there is no binocular single vision.

RETINAL CORRESPONDENCE:

According to Bagolini, it is area to area relationship, not point to point relationship. Images falling on corresponding locations in each eye create a single mental impression.

- NORMAL RETINAL CORRESPONDENCE – both foveae project to one visual direction
- ANOMALOUS RETINAL CORRESPONDENCE (ARC) – when fovea of one eye has common visual direction with extrafovea of the other eye. ARC has two types, Harmonious when the angle of anomaly is equal to the angle of strabismus. Unharmonious when the angle of anomaly is less than the angle of strabismus[11].

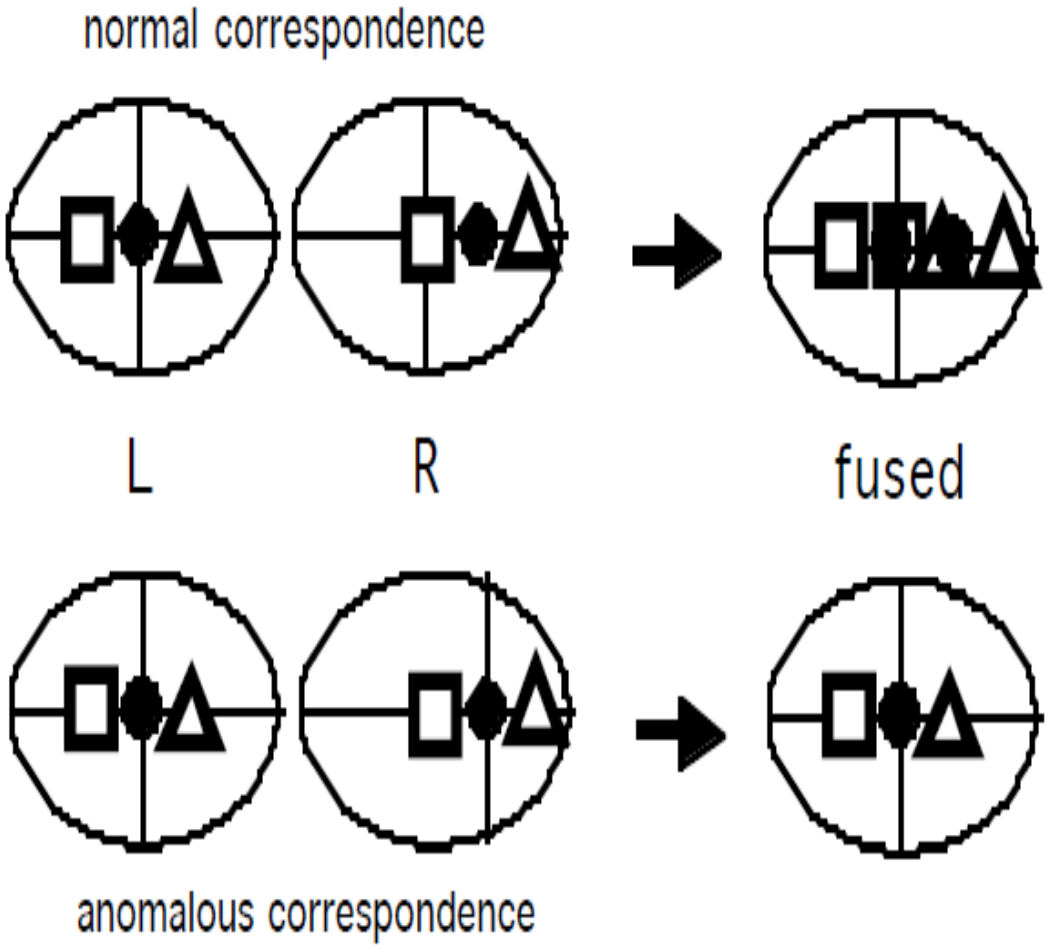


Fig8. Diagrammatic representation of normal and anomalous retinal correspondence

EVALUATION OF THE PATIENT

HIRSCHBERG TEST:

It is a rough objective estimate of the angle of manifest deviation. A torch is shone at arm's length and patient is asked to fix. The amount of decentration of corneal reflex gives the degree of deviation. Each mm of deviation is approximately 7 degrees[12].

KRIMSKY TEST:

Here, corneal reflex test is combined with prisms in front of fixing eye. Prisms are placed until corneal reflections are symmetrical.

COVER-UNCOVER TEST:

The first part of the test, cover test is used to detect heterotropia. Here examiner covers one eye and looks for the refixation movement of the other eye.

In uncover test, heterophoria is detected. Here, the examiner covers right eye and after few seconds removes the cover. No movement means orthophoria. If one eye deviates under cover, a refixation movement is observed in that eye on being uncovered.

ALTERNATE COVER TEST:

This is basically a dissociation test which identifies total deviation when fusion is suspended. It is done after cover-uncover test. A patient with well compensated heterophoria will have orthophoric eyes before and after the test has been done, but the patient with poor control may decompensate to a manifest deviation.

PRISM BAR COVER TEST:

After alternate cover test, prisms of increasing strength are placed in front of eye with apex towards the side of deviation. Alternate cover test is continuously performed. When the end point is approached no movement is seen.

WORTH'S FOUR DOT TEST:

This is a dissociative diplopia test using complementary colours. This is done at 33cm and 6m. The patient wears a Red- Green goggle with red over right eye and looks at a diamond pattern light illuminated from within, with 4 lights- one red one white and two green. The results could be interpreted as-

INTERPRETATION:

Normal – 2 green, 1 red, 1 white dot

Suppression left – 2 red

Suppression right – 3 green

Diplopia – 5 dots, crossed or uncrossed

Harmonious ARC – 4 dots in the presence of a manifest squint.

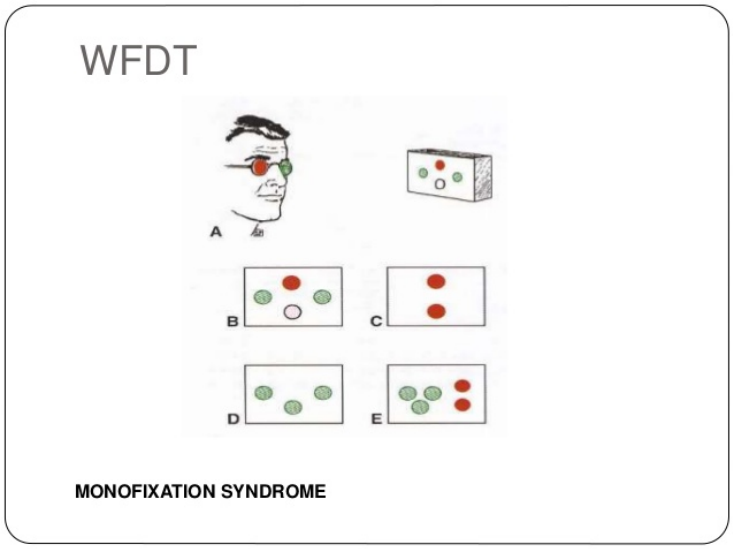


Fig9. Worth four Dot test.

STEREOPSIS TESTS:

Stereoacuity is the quantitative measure of the stereopsis, it refers to the smallest horizontal retinal image disparity that gives rise to depth perception. It is measured in seconds of arc.

1 degree = 60 minutes of arc. 1 minute = 60 seconds of arc.

Normal stereoacuity is less than 60 seconds of arc. The lower the value, the better the acuity.

QUALITATIVE TESTS:

RANDOM DOT STEREOGRAM

SYNOPTOPHORE

SYNOPTOPHORE:

Fig10. Synoptophore

It can test all grades of binocular single vision.

Grade 1, simultaneous macular perception is tested by using two dissimilar pictures a lion and a cage. The two viewing tubes are either subjectively or objectively adjusted so that the lion is perceived to be inside the cage.

Grade 2, fusion is tested by using two similar pictures incomplete in atleast one detail. One tube is locked and patient is asked to adjust the other tube to produce a composite picture.

Grade 3, stereopsis is tested by using two slides of same object, taken from a slightly different angle to produce depth sensation. The patient is asked to describe the apparent effect i.e., to describe if the swing is moving towards or away from them.

QUANTITATIVE TESTS:

TITMUS FLY TEST

TNO TEST

LANG TEST

TITMUS FLY TEST:

It has two plates, the first with a fly and 3 rows of animals[13]. If a person is able to appreciate the wings of the fly standing out from the body, wearing the Polaroid glasses, then gross stereopsis is said to be present. Then if one animal on each row appears to stand out a stereopsis of 100□□ is said to present.

The second plate has nine boxes with four circles each. In each, atleast one circle is displaced to produce disparity, achieving a stereopsis of 40^{o}

Fig 11.Titmus Fly test

SURGICAL MANAGEMENT

Strabismus surgery aims to restore the binocular vision rather than just cosmetic correction. Strabismus surgery also has its own psychosocial benefits and expands the binocular fields. The literature also gives evidence of improvement in diplopia, motor fusion, stereoacuity. These effects are more pronounced when the strabismus surgery is performed soon before the visual system matures. Results are particularly best if done before the age of 2 years[14]. There are enough literature evidences to support restoration of some, atleast a perverted form of binocularity in these patients who undergo strabismus surgery after 2 years of age.

SURGICAL ANATOMY:

SPIRAL OF TILLAUX – INSERTION OF RECTI MUSCLES

It is an imaginary line joining the insertions of the four recti muscles and is an important landmark anatomically, while performing surgery. The insertions are located progressively further away from the limbus in a spiral pattern, medial rectus being closest and superior rectus being farthest[15].

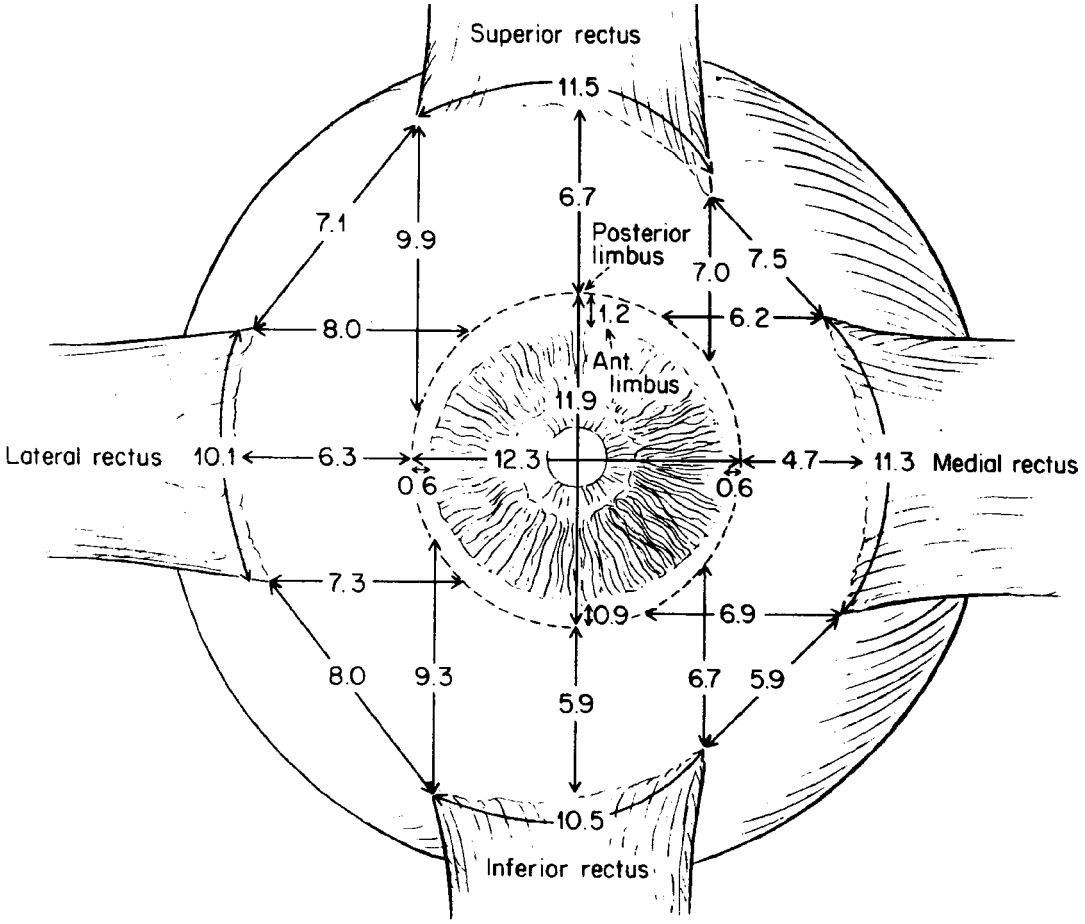


Fig 12. Spiral of Tillaux showing the distance between limbus and insertion of recti muscles.

SURGERY ON THE RECTUS MUSCLE

STANDARD RECTUS RECESSION

The medial rectus is detached from the globe and reinserted further away from the limbus. This shortens the distance between the point where the muscle originates and inserts, in essence, weakens it[16].

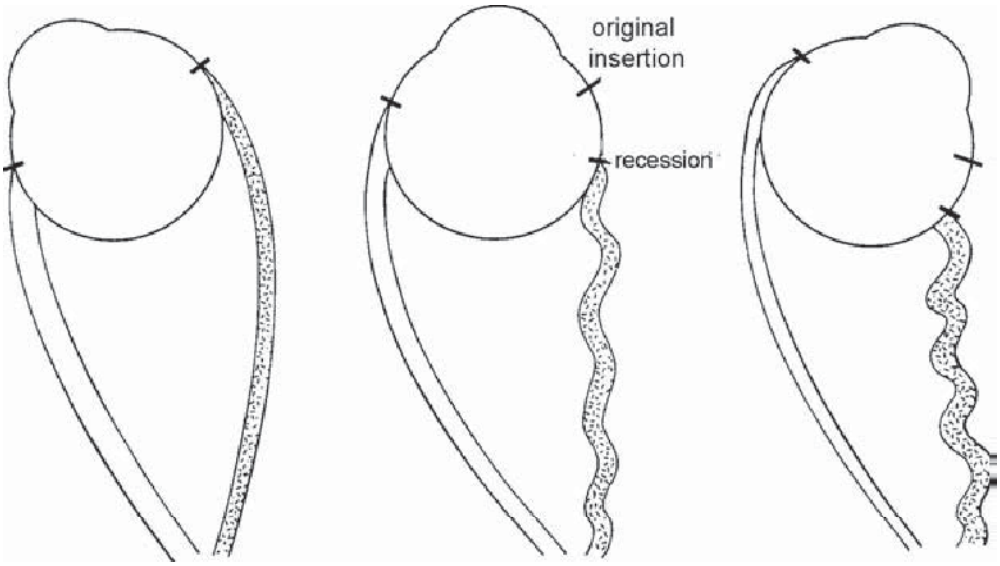


Fig13. Diagram showing the effect of muscle recession

METHOD:

1. The eye is painted, draped and speculum inserted. Two limbal traction sutures are placed through the conjunctiva and episclera.
2. A conjunctival peritomy is made around the limbus in the region of the muscle.

3. The subconjunctival space is dissected down on either side of the muscle using Wescott scissors in a spreading fashion. Dissection is not done directly over the muscle as this tends to bleed.
4. A muscle hook is passed into this area and muscle hooked.
5. The tenon's capsule is cleaned from the muscle, using blunt dissection.
6. A 6-0 absorbable suture is applied into each outer third of the muscle at its insertion, by passing two throws of the suture – one partial thickness and one full thickness.
7. The muscle is disinserted from the sclera using Wescott scissors, without cutting the suture.
8. The distance of recession is measured with the calipers.
9. The suture is then anchored into sclera making a partial thickness scleral bite.
10. The conjunctiva and tenon's are closed in layers with 6-0 absorbable sutures[17] and injection 0.5 ml dexamethasone given subconjunctivally.

STANDARD RECTUS RESECTION:

The calculated length of the muscle is excised, this shortens it by strengthening the muscle[18].

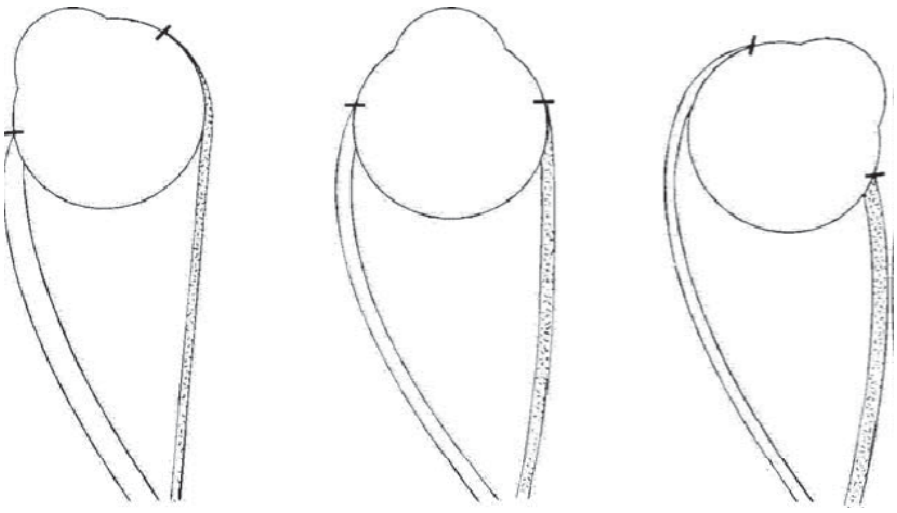


Fig14. Diagram showing the effect of muscle resection

METHOD:

1. Step 1 to 5 are same as for medial rectus.
2. The length of the lateral rectus muscle to be resected is measured using calipers. 6-0 absorbable suture is placed into each outer third of the muscle at its insertion, by passing two throws of the suture – one partial thickness and one full thickness.
3. A straight artery forceps is applied across the muscle, proximal to the sutures and the muscle is gently crushed.
4. The muscle is cut across at this site using Wescott scissors, taking small bites at least 1 mm proximal to the sutures.

5. The muscle is held by the sutures, pulled towards the insertion and inspected to ensure it is not twisted.
6. The suture on the lower third of the muscle is passed through the lower end of the previous muscle insertion. The same is done with the upper suture so ensuring that the muscle is spread in full width.
7. The muscle is checked for any sagging. If found, an extra suture is applied through this and tied upto the insertion.
8. The tenon's and conjunctiva are closed in layers with 6-0 absorbable sutures and injection 0.5 ml dexamethasone given subconjunctivally.

DEGREE OF CORRECTION FOR 1 MM MEDIAL RECTUS:

Recession – 1.5 Degrees

Resection – 2.5 Degrees

Recession –6-7 mm maximum and 3 mm minimum

Resection – 8-10 mm maximum and 4 mm minimum[19]

DEGREE OF CORRECTION FOR 1 MM LATERAL RECTUS:

Recession – 1 degree

Resection – 2 degree

Recession – 8-10mm maximum and 5 mm minimum

Resection – 12-14 mm maximum and 4 mm minimum[20]

PART - II

AIMS AND OBJECTIVES

AIMS AND OBJECTIVES

Primary Objective:

To study postoperative binocular single vision obtained by patients older than 2 years of age with various types of strabismus, after surgical correction.

Secondary Objective:

To study the effect of age at the time of strabismus surgery on stereopsis of eye.

MATERIALS

AND METHODS

MATERIALS AND METHODS

Subject Selection:

50 patients attending Ophthalmology OPD diagnosed with horizontal concomitant squint during the one year period (June 2014-June 2015).

Inclusion Criteria:

1. Age group: 3 to 40 years of age with constant strabismus
2. Type of squint: horizontal strabismus, including convergent and divergent squint.
3. Type of surgeries done: Recession – Resection surgery and Bimedial Recession.

Exclusion Criteria:

1. Patients with vertical strabismus
2. One eyed patients
3. Poor vision due to other causes
4. Previous strabismus surgery
5. Paralytic squint

OCULAR EXAMINATION:

1. Head position – head tilt, face turn, chin elevation/depression were noted.
2. Extra ocular movements were noted both ductions and versions.
3. Pupil size, shape and reaction noted.
4. Anterior segment examined in detail with slit lamp.
5. A dilated fundus and refraction was done.
6. Complete orthoptic evaluation was done.
7. Binocular single vision assessment was done with worth four dot test, and grading done with synoptophore and titmus fly test preoperatively and during postoperative follow up visits and compared.
8. Amount of residual deviation also noted with prism bar cover test during follow up visits.

RESULTS

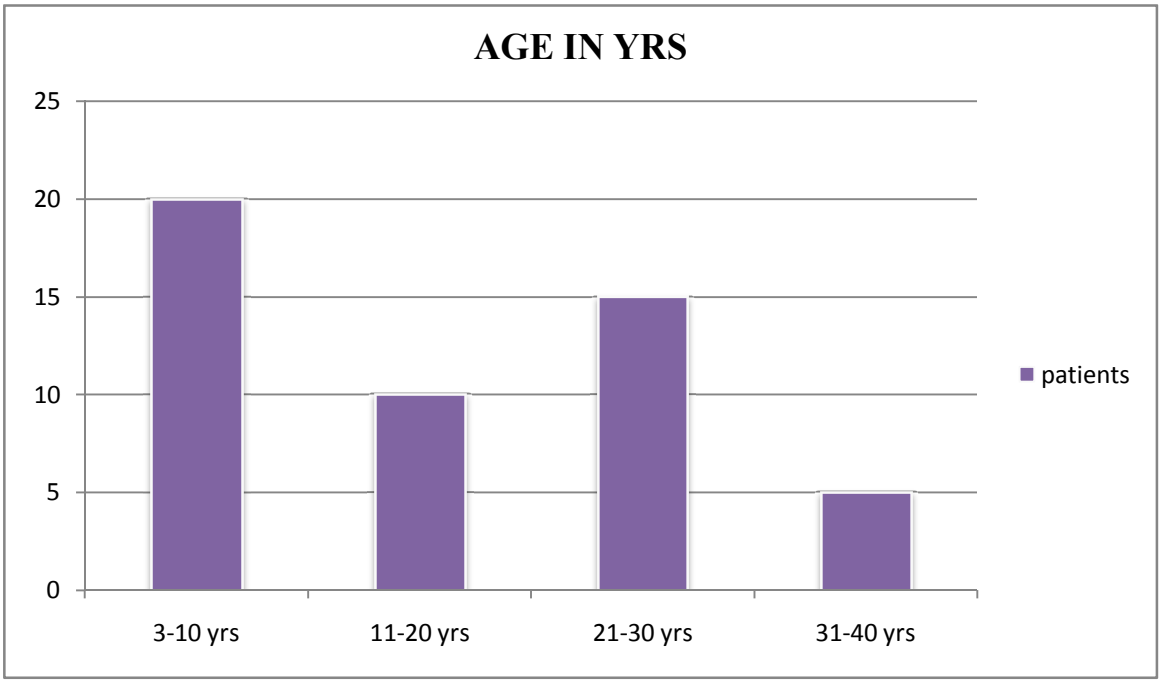
RESULTS

TABLE 1: AGE DISTRIBUTION

The following table shows the age distribution in the patients who underwent study.

AGE	PATIENTS	%
3-10 YRS	**20**	**40**
11-20 YRS	10	20
21-30 YRS	15	30
31-40 YRS	5	10
TOTAL	**50**	**100**

GRAPH 1: AGE DISTRIBUTION



In our study the maximum number of patients belonged to the age group of 3-10 years (40%), followed by 21-30 years (30%).

In the Orbis study done at Little flower hospital, Angamaly, the age inclusion criteria was patients between 4 to 36 years[21].

TABLE 2. SEX DISTRIBUTION

Sex	Frequency	%
Males	23	46
Females	27	54
TOTAL	**50**	**100**

In our study, there was a significant gender difference, with 27(54%) females against 23 (46%) males. One of the reasons for this significant could be due to the fact that females are more concerned about cosmetic appearance and hence seek early intervention.

GRAPH 2: SEX DISTRIBUTION

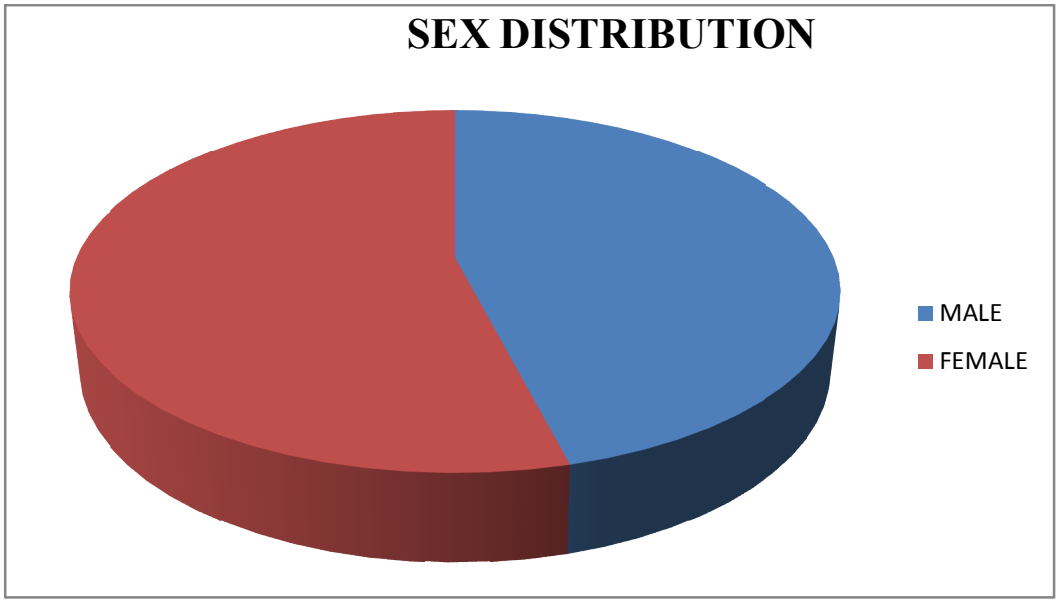
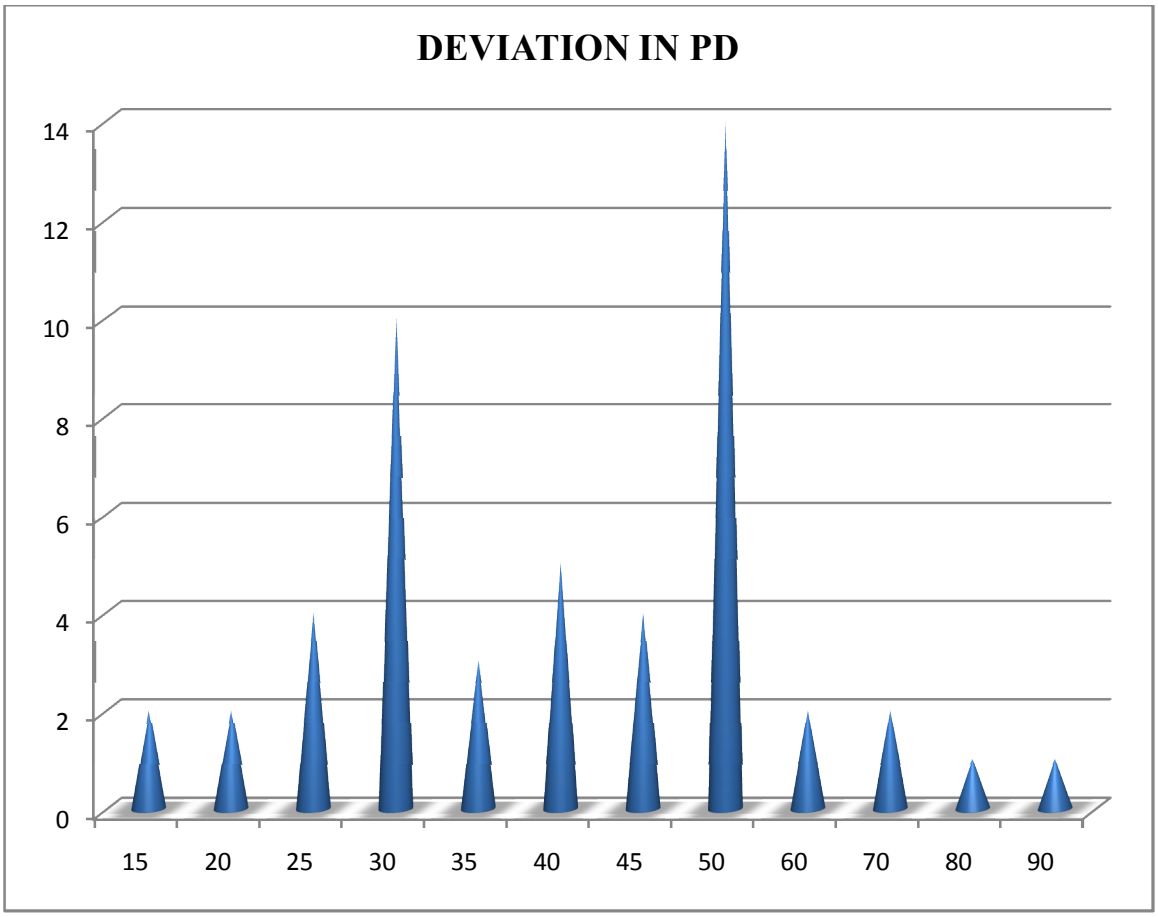


TABLE 3: DEVIATION IN AFFECTED EYES

Primary Deviation In PD	Frequency	%
15	2	4
20	2	4
25	4	8
30	**10**	**20**
35	3	6
40	5	10
45	4	8
50	**14**	**28**
60	2	4
70	2	4
80	1	2
90	1	2
TOTAL	**50**	**100**

GRAPH 3: DEVIATION IN PD



In our study maximum number of patients had a primary deviation of 50 PD (28%), followed by 30 PD (20%) and least by 80 and 90 PD with 2% each.

Preoperative amount of deviation determines the amount of residual deviation and hence the prognosis for achievement of binocularity.

TABLE 4: PATIENTS DISTRIBUTION BY TYPE OF DEVIATION

Type of deviation	Number of patients	%
Esotropia	20	40
Exotropia	30	60
Total	50	100

In our study, 30 patients had exotropia(60%) whereas only 20 patients had esotropia(40%). This is significant with a p value <0.05. In the Orbis study at Little flower hospital, Angamaly, of the 29 patients 10 had esotropia and 19 had exotropia.

GRAPH 4: PATIENTS DISTRIBUTION BY TYPE OF DEVIATION

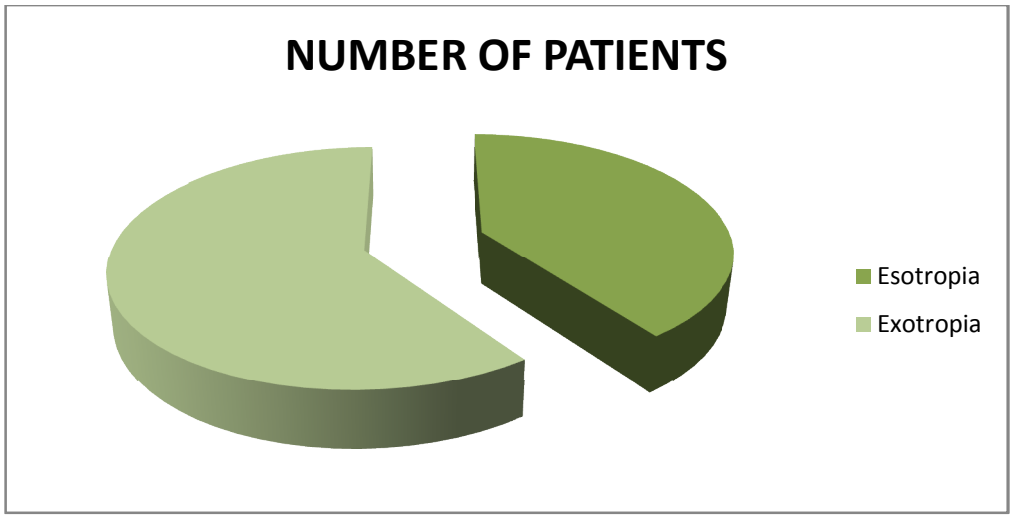


TABLE 5: TYPE OF SURGERY PERFORMED IN PATIENTS

Type Of Surgery	Number Of Patients	Frequency
Bimedial Recession	6	12
Recession - Resection	44	88
Total	50	100

In our study, surgical alignment for squint was done with either bimedial recession or Recession-Resection surgery[22]. 44(88%) patients underwent R-R and bimedial recession was done in 6(12%) patients. In

GRAPH 5: TYPE OF SURGERY PERFORMED IN PATIENTS

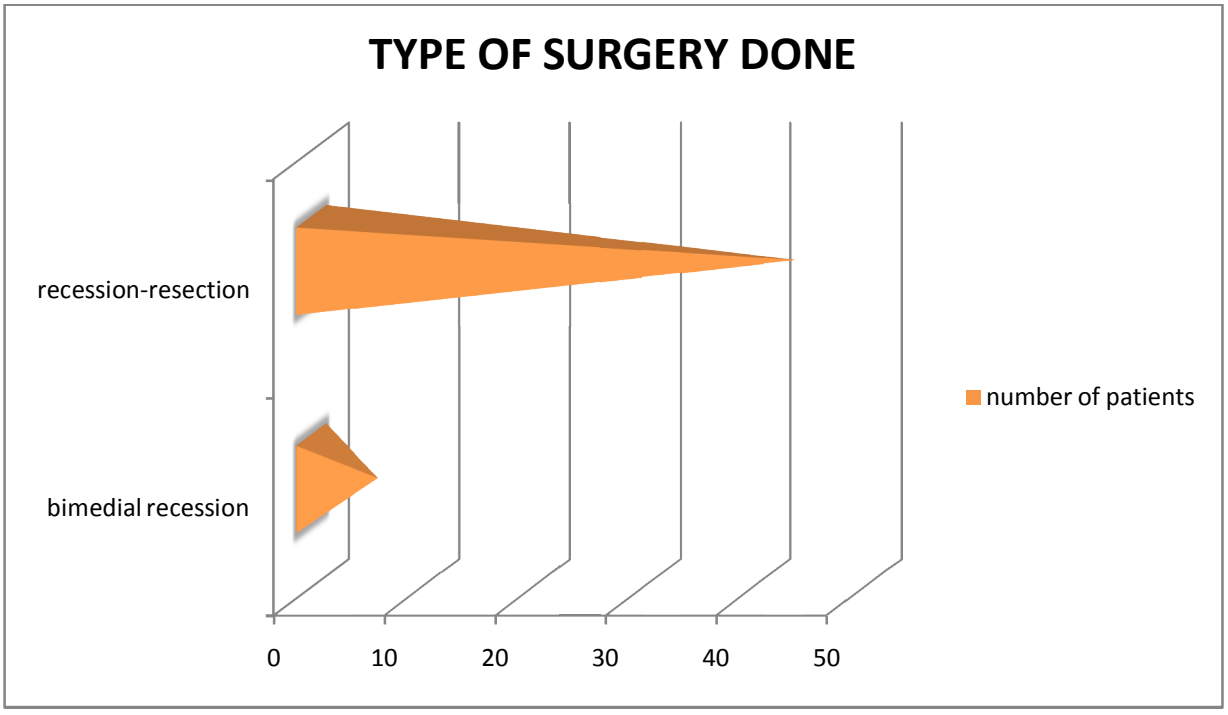


TABLE 6: PREOPERATIVE BINOCULAR SINGLE VISION

BSV	Frequency	%
Present	3	6
Absent	47	94
Total	50	100

This table shows the frequency of binocular single vision prior to the surgery. Only 3 patients (6%) had preop BSV when tested with worth four dot test. Most of patients did not have preop BSV 47(94%). This is significant with a p value < 0.05.

GRAPH 6: PREOPERATIVE BINOCULAR SINGLE VISION

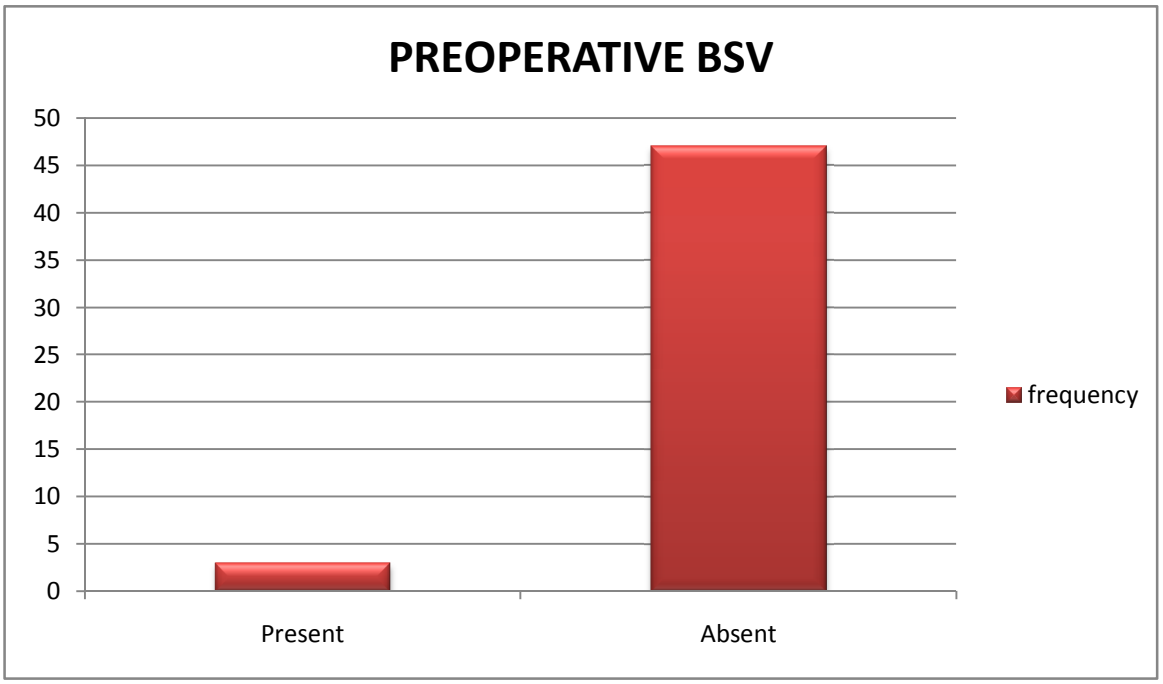
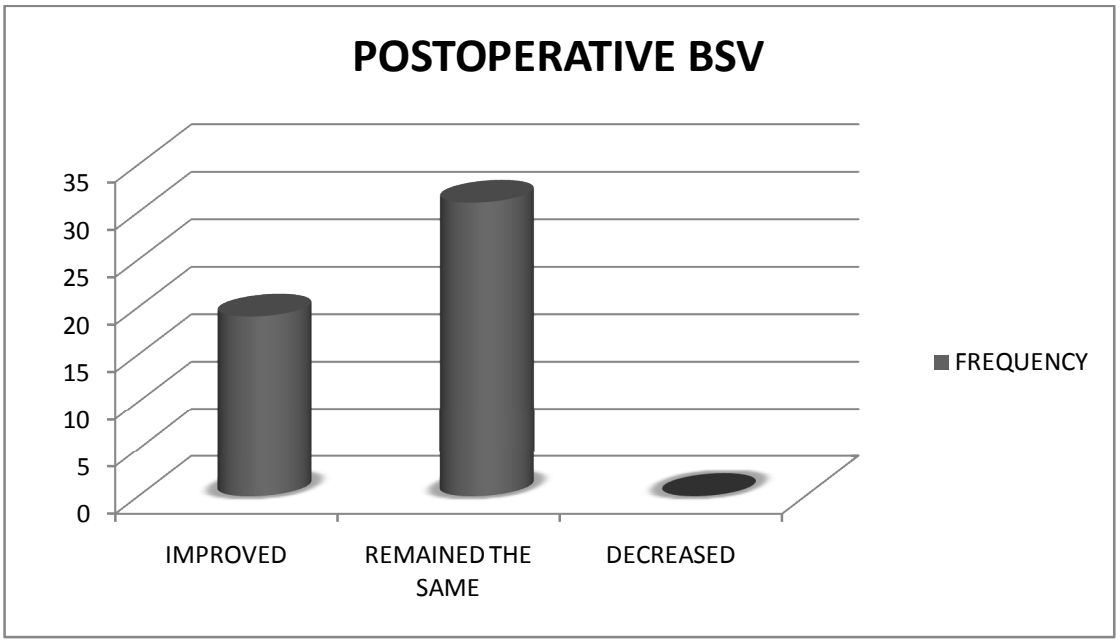


TABLE 7: POSTOPERATIVE BINOCULAR STATUS

Postop binocular vision	Frequency	%
Improved	19	**38**
Remained the same	31	62
Decreased	0	0
Total	50	100

Following surgery, the patient's binocular status was analysed with WFDT, synoptophore and titmus fly test. Of the 50 patients tested, only 19(38%) patients showed some improvement in BSV on testing with WFDT. Most of the patients 31(62%) remained the same without any improvement in binocularity. However none of them showed decrease in binocularity after surgery.

GRAPH 7: POSTOPERATIVE BINOCULAR STATUS



In the Orbis study, of the 29 patients who underwent Recession-Resection surgery, 5 patients attained stereoacuity (26%).

In another study by Marilyn B. Mets et al[23], of the 72 patients who underwent bimedial recession, 30 patients showed improved binocular function, 38 remained the same and 4 had decreased binocularity postoperatively.

TABLE 8: IMPROVED BINOCULAR FUNCTION

Improved BSV	frequency	%
With Synoptophore	16	84
With Titmus test	3	16
Total	19	100

This table shows the degree of improvement in binocularity following surgical alignment. Of the 19 patients who had improved binocularity with WFDT, 16(84%) patients showed improvement when tested with a synoptophore and 3(16%) showed improvement with Titmus fly chart.

GRAPH 8: IMPROVED BINOCULAR FUNCTION

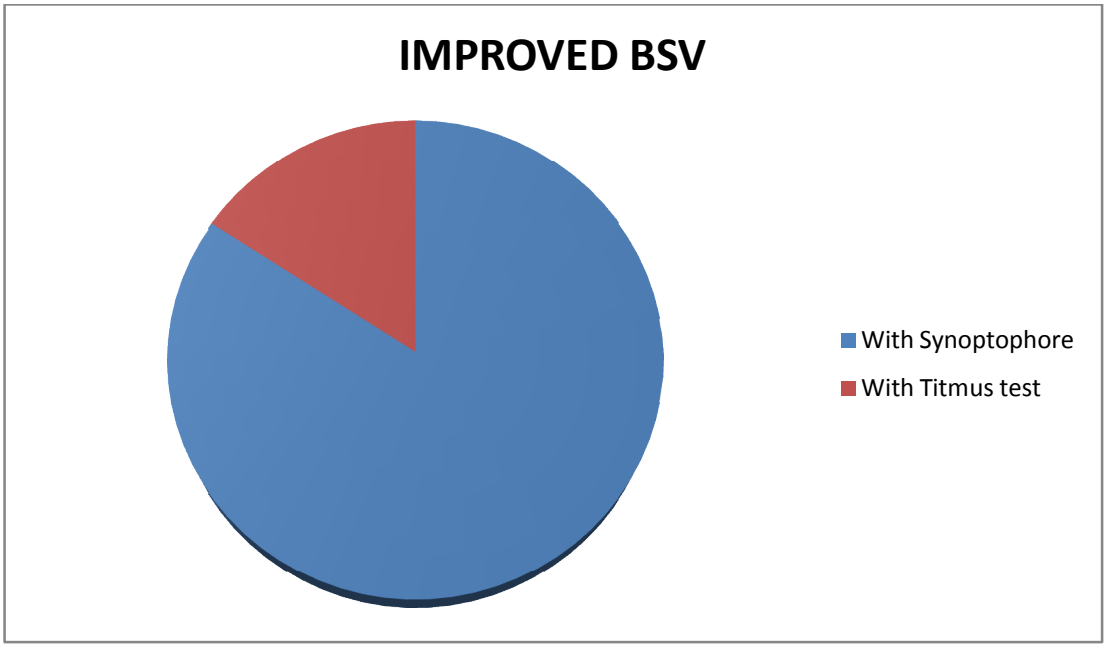


TABLE 9: GRADE OF BSV ACHIEVED POSTOPERATIVELY WITH SYNOPTOPHORE

GRADE OF BSV	FREQUENCY	%
1	9	56
2	4	21
3	3	14
TOTAL	16	100

In this study, 16 patients showed binocular improvement with synoptophore. 9(56%) showed grade 1 improvement from absent BSV prior to surgery, 4(21%) showed grade 2 and 3(14%) showed grade 3 improvement.

This is significant as even grade 1 improvement of binocularity can improve the quality of vision.

GRAPH 9: GRADE OF BSV ACHIEVED POSTOPERATIVELY WITH SYNOPTOPHORE

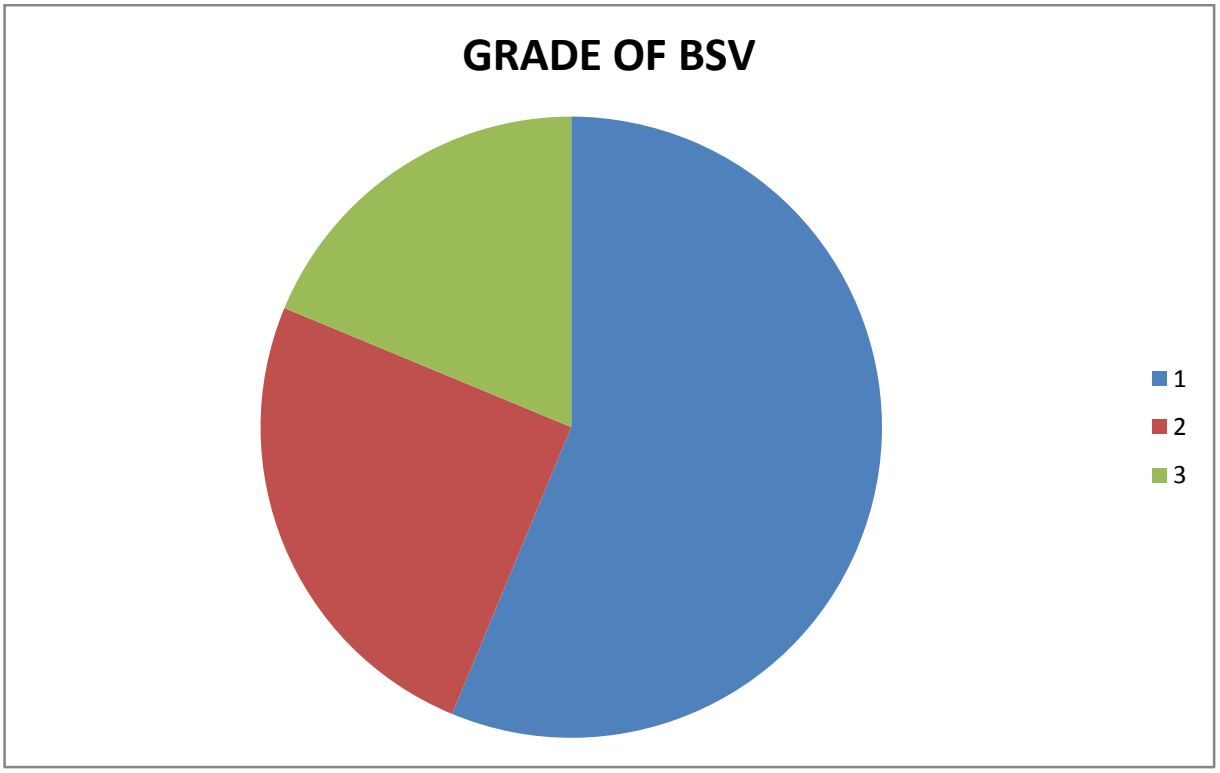


TABLE 10: BSV ACHIEVED IN ESOTROPES AND EXOTROPES

BSV IN	FREQUENCY	%
ESOTROPES	0	0
EXOTROPES	19	19
TOTAL	19	100

In our study, we compared the binocularity achieved in esotropes versus exotropes. Of the 19 patients who showed improvement in binocular function, none of them were esotropes. All the 19 patients had preop exotropia. This is statistically significant with a p value <0.05.

In the Orbis study, none of the esotropes achieved stereoacuity. All the 5 patients who showed stereoacuity were exotropes.

GRAPH 10: BSV ACHIEVED IN ESOTROPES AND EXOTROPES

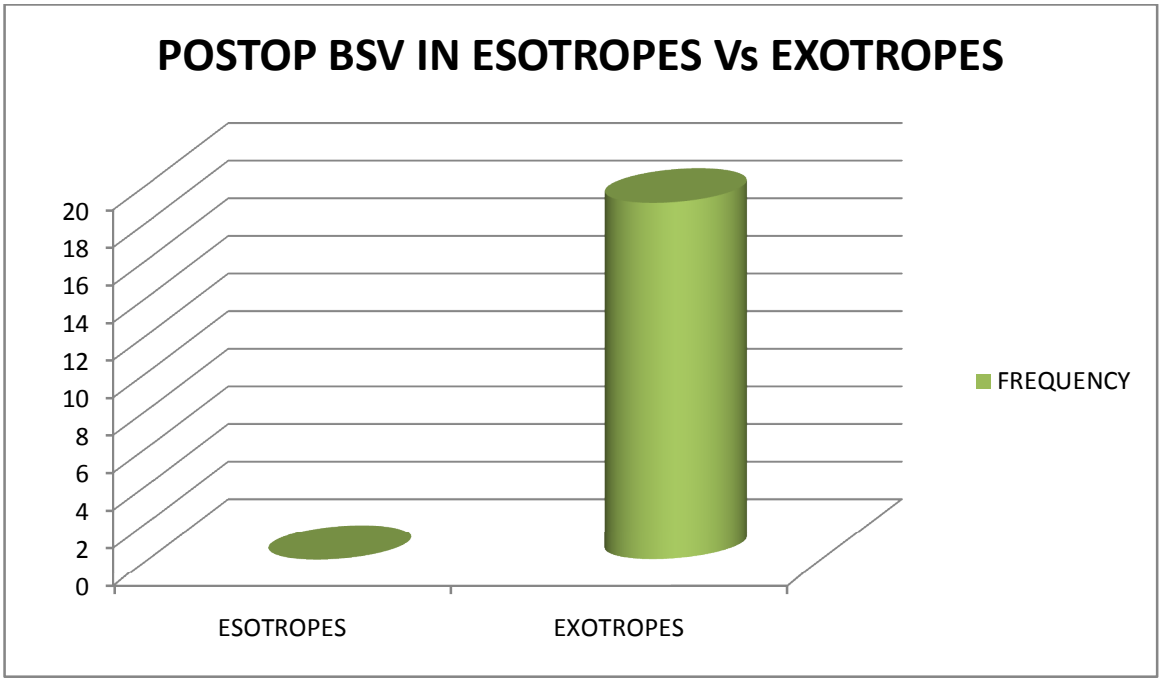


TABLE 11: EFFECT OF AGE ON BINOCULAR VISION ACHIEVED POSTOPERATIVELY

Age in yrs	BSV Present	%
3-10	14	82
11-20	5	18
21-30	0	0
31-40	0	0
Total	19	100

The study also compared the effect of age on the binocularity achieved postoperatively. 19 patients showed improvement in BSV with WFDT. Of these, 14(82%) belonged to 3-10 yr age group. This is statistically significant with a p value <0.05. The remaining patients belonged to 11-20 age group 5(18%)

GRAPH 11: EFFECT OF AGE ON BINOCULAR VISION ACHIEVED POSTOPERATIVELY

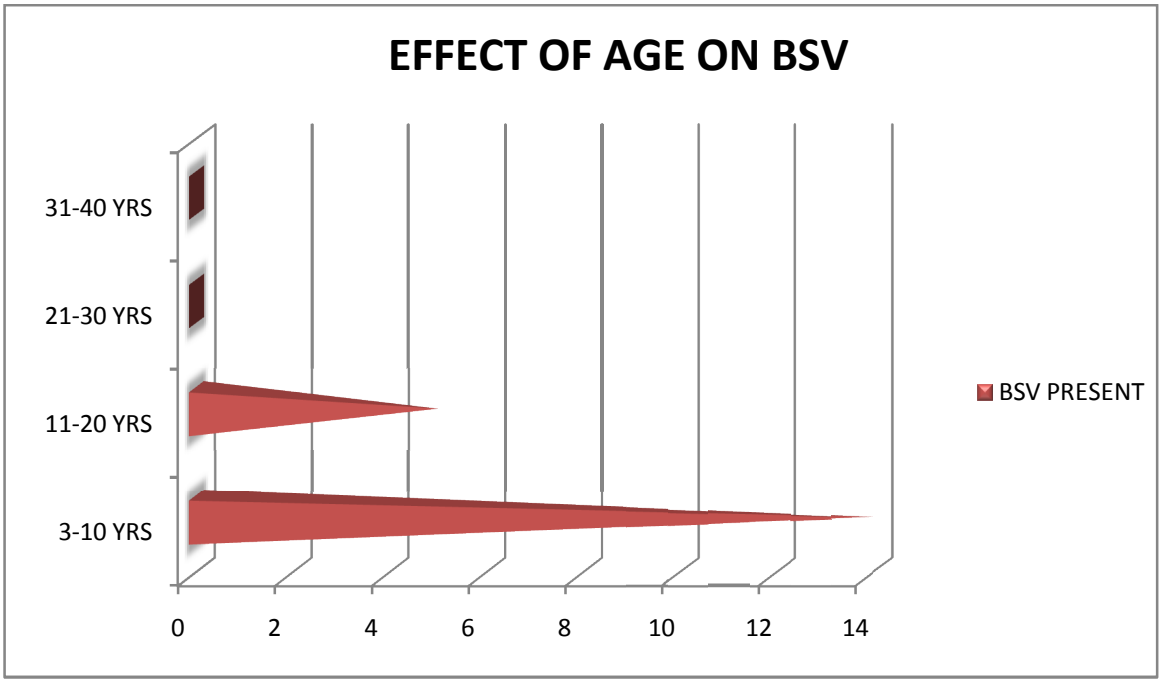


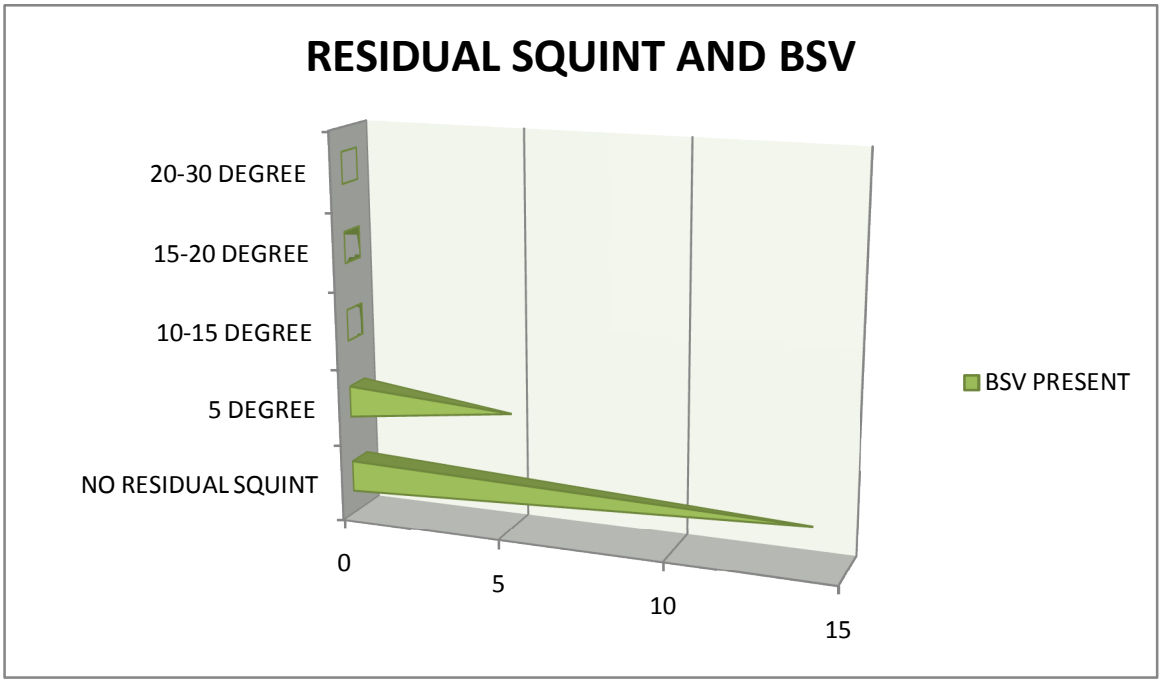
TABLE 12: EFFECT OF RESIDUAL SQUINT ON DEVELOPMENT OF BINOCULAR FUNCTION

Amount of residual squint	BSV present	%
No residual squint	14	74
5 degree	5	26
10 - 15degree	0	0
15 - 20 degree	0	0
20 - 30 degree	0	0
Total	19	100

We also studied the correlation between the binocularity achieved and the amount of residual squint. 14(74%) patients who achieved binocularity did not have any residual squint. 5(26%) had a residual 5 degree.

In the Orbis study, of the 29 patients who underwent surgery, 5 patients showed improved stereoacuity. 31% patients with no residual squint achieved stereoacuity, 10% patients with residual 5 degree squint achieved stereoacuity. None of the patients with more than 5 degree i.e., 10 PD achieved stereoacuity.

GRAPH 12: EFFECT OF RESIDUAL SQUINT ON DEVELOPMENT OF BINOCULAR FUNCTION



DISCUSSION

1. AGE

In this study, 50 patients with horizontal concomitant squints were studied. The maximum number of patients belonged to the age group of 3-10 years (40%) and 21-30 years (30%). The prognosis for binocularity is high in this age group due to pliability of the immature visual system.

The type of squint also varies depending on the age with esotropia more common in younger persons and exotropia being common in the rest. The generally accepted dictum is stimulus deprivation less than 5 years leads to esotropia and after 5 years leads to exotropia. Younger patients are able to overcome diplopia due to suppression. Cosmetic appearance is also of greater concern in patients of younger age group.

Binocular single vision achievement depends on plasticity of the visual system. The general belief is that BSV is achieved best when surgical alignment is carried out before the age of 2 years. In this study we try to look for the BSV establishment for patients of more than 2 years too, without denying surgical correction.

In Orbis study, done at the Little flower hospital, Angamaly, the inclusion criteria included patients between ages of 4 to 36 years.

2. SEX

In our study conducted on 50 patients, females were higher than males, with 27(54%) against males 23(46%).

Since females are more concerned about their cosmetic appearance this seems to be a reason for more female patients undergoing surgery in our study.

3. DEVIATION IN PRISM DIOPTRES

In our study, the amount of deviation was measured with prism bar cover test. In general, primary deviation is equal to secondary deviation in concomitant squints.

Of the 50 patients, the maximum 14(28%) had 50PD deviation, including both eso and exotropia, followed by 10(20%) 30 PD deviation and the least by 80 PD and 90 PD 1 (2%) each.

This is significant because the larger the preoperative deviation, the larger the residual amount of deviation. The more residual squint, the less is the chance of BSV establishment.

Thus the degree of primary deviation at presentation is a very good predictor of the recovery of BSV.

4. PATIENTS DISTRIBUTION BY TYPE OF DEVIATION

In our study, of the 50 patients, 20(40%) had esotropia and 30(60%) had exotropia. This is statistically significant with p value of <0.05 when tested with Z test for 2 population proportions.

BSV recovery depends on the type of deviation also. With esotropia early in the childhood, the eyes go for alternate fixation and cross fixation. This avoids dense amblyopia. But the chance of BSV recovery becomes slim because cortical fusion mechanism is not established.

In exotropia, usually the patients are orthophoric initially. Exotropia passes through stages of exophoria, intermittent exotropia and finally manifest exotropia. So usually during the initial plastic stages of the visual system, some amount of BSV recovery becomes possible if the corrective surgery is done quick enough.

5. TYPE OF SURGERY PERFORMED IN PATIENTS

In our study, two types of corrective squint surgeries were performed. Bimedial recession is a medial rectus weakening procedure done for esotropias in young children. Recession is a better option than resection in very young children with esotropias. The other surgery is the standard Recession-Resection done for both esotropias and exotropias.

For correcting esotropia, the general rule is to recess the MR and resect the LR. For exotropia, we recess the LR and resect the MR. The standard nomogram for the amount of recession/resection for each degree of squint correction was followed[24].

In this study, we did 6(12%) bimedial recession and 44(88%) recession-resection surgeries. As the number of patients with exotropia was more, we had more of recession-resection surgeries. This is statistically significant with a p value of <0.01 when tested with Z test for 2 population proportions.

6. PREOPERATIVE BINOCULAR SINGLE VISION

In our study, 3 (6%) had BSV prior to surgery and 47(94%) did not have BSV when tested with worth four dot test. The primary objective of this study is to improve some gross BSV with surgical correction. This will help to improve the quality of vision.

7. POSTOPERATIVE BINOCULAR STATUS

In this study 19(38%) showed improvement in binocular status when tested with Worth four dot test postoperatively. No patient showed any decrease in the existing binocular status and 31(62%) had the same binocular status postoperatively too.

Binocular testing is carried out at each postop visit as per schedule and the 3 month postoperative binocular status is taken for consideration in this study.

The binocular improvement is not highly significant at $p<0.05$ with a p value of 1 when tested with chi^2 test. There are several factors affecting the postoperative binocularity especially the degree of amblyopia prior to surgery[31,32]. Before taking the patients for corrective surgical alignment, amblyopia management with occlusion therapy and best refractive correction is carried out. The orthoptic exercises are continued for 1 month and then patients are taken up for surgery.

The surgical alignment itself will take care of the amblyopia later as it aids in binocular fusion unless severe amblyopia has set in, leading to suppression[25].

8. IMPROVED BINOCULAR FUNCTION

The 19 patients who showed improvement with the Worth four dot test were later tested for the degree of binocularity with synoptophore and titmus fly test.

Synoptophore gives the grades of binocular function with grade 1 being simultaneous macular perception, 2 fusion and 3 stereopsis. Of the 19 patients, 16 (84%) showed improvement with synoptophore and 3(16%) showed stereoacuity with titmus fly test.

9. GRADE OF BSV ACHIEVED POSTOPERATIVELY WITH SYNOPTOPHORE

Of the 16 patients who showed improvement with synoptophore, 10 (56%) had grade 1, 4(21%) had grade 2, 3(14%) had grade 3 Binocular single vision. This improvement is significant as even a single grade improvement in BSV can enhance the quality of vision and decrease the chances of amblyopia.

10. BSV ACHIEVED IN ESOTROPES AND EXOTROPES

Of the 19 patients who showed improvement in binocular function, none were esotropes. All the 19 patients had preop exotropia. This is statistically significant with a p value <0.05.

The exotropes probably had intermittent exotropia in their childhood, thus having some potential for BSV establishment. O'neal[26] and his colleagues carried out strabismus surgery on 20 intermittent exotropes aging and studied the stereoacuity with Titmus test at near and Mentor B-Vat test at distance. Stereoacuity improved in 75% at near and 45% at distance.

P.E. Waddingam[27] found that the persons with constant exotropia had increased chances of stereoacuity(30.8%). Thus we can conclude that persons with exotropia have a better shot at binocularity when compared to esotropia, if the eyes are properly aligned surgically.

This advantage the exotropes enjoy may be due to the fact that manifest exotropia passes through several stages[30]. 1. Exophoria 2. Intermittent exotropia 3. Manifest exotropia. (as suggested by Jampolsky).

Lang's research[28] (1958) also supports this fact, wherein he found that 58% of the exotropic children had intermittent deviation and 34% of adults had intermittent exotropia.

11: EFFECT OF AGE ON BINOCULAR VISION ACHIEVED POSTOPERATIVELY

The study also compared the effect of age on the binocularity achieved postoperatively. 19 patients showed improvement in BSV with WFDT. Of these, 14(82%) belonged to 3-10 yr age group. This is statistically significant with a p value <0.05. The remaining patients belonged to 11-20 age group. 5(18%)

The fact that surgical alignment before 2 years of age maximizes the chance for BSV is true. But this study aims to highlight the importance of strabismus surgery in recovery of BSV in older children too. After 2 years, the age of the patient comes into consideration. As found in this study, if children are within 10 years of age, the chance for BSV improvement is high, with the best results seen in children with exotropia.

Keith Lyle [29]says “constant primary divergent squint in which the squint was originally an intermittent one, if there is good visual acuity in each eye there is always a possibility of achieving good binocular vision”.

12: EFFECT OF RESIDUAL SQUINT ON DEVELOPMENT OF BINOCULAR FUNCTION

We also studied the correlation between the binocularity achieved and the amount of residual squint. 14(74%) patients who achieved binocularity did not have any residual squint. 5(26%) had a residual 5 degree.

Majority of the patients who achieve orthophoria after squint corrective surgery have good chances of binocularity as shown by our study. There were no untoward complications noted in any of the strabismus surgeries and the patient satisfaction for the procedure was high.

CONCLUSION

CONCLUSION:

1. Attainment of stereopsis, the highest grade of binocular single vision, depends on many factors, including preoperative visual acuity, refractive status, amount of deviation and residual deviation postoperatively.

2. The type of squint also dictates the level of binocularity achieved. In this study, none of the esotropes achieved BSV postoperatively. As the exotropes initially pass through stages of exophoria and intermittent exotropia, the chance of binocular development in this group is high.

3. Stereopsis is best achieved if surgical alignment is done before 2 years of age. This study proves that patients will benefit even if surgery is carried out after 2 years of age. However, the benefit varies age wise again with less than 10 years giving a favourable prognosis.

4. The amount of residual squint also alters the binocular status. Patients who are orthophoric postoperatively had high chances of BSV. Acceptable binocularity was restored with residual deviation till 10 PD. Beyond that none of the patients showed binocularity.

CLINICAL PREOP AND POST OP PHOTOGRAPHS:






CLINICAL PREOP AND POST OP PHOTOGRAPHS:






CLINICAL PREOP AND POST OP PHOTOGRAPHS:






PART – III

BIBLIOGRAPHY

1. GUNTER K. VON NOORDEN: BINOCULAR VISION AND OCULAR MOTILITY, THEORY AND MANAGEMENT OF STRABISMUS [1,2,4,5,15].
2. THEORY AND PRACTICE OF SQUINT AND ORTHOPTICS: AK KHURANA [3,19,20]
3. KEITH LYLE J, KENNETH C.WYHAR: PRACTICAL ORTHOPTICS IN TREATMENT OF SQUINT[29]
4. DISTANCE STEREOACUITY IMPROVEMENT IN INTERMITTENT EXOTROPIC PATIENTS FOLLOWING STRABISMUS SURGERY: O'NEAL ET AL. J PEDIATRIC OPHTHAL STRABISMUS 1995 NOV-DEC[26]
5. THE PROGRESS OF INTERMITTENT EXOTROPIA: WEI Y ET AL. ZHONGHUA YAN KE ZA ZHI 2011 NOV. READ JC, EYE LONDON 2015 FEB[30]
6. FUSION AFTER SURGICAL CORRECTION OF LONGSTANDING STRABISMUS IN ADULTS: MORRIS RJ ET AL, OPHTHALMOLOGY 1993[31]
7. PREDICTORS OF POSTOPERATIVE BINOCULARITY IN ADULT STRABISMUS.: UMAZUME F ET AL, JPN J OPHTHAL 1997 NOV-DEC[32]

8. FIONA J. ROWE: CLINICAL ORTHOPTICS[8,10,11,25]

9. COLOUR ATLAS OF STRABISMUS SURGERY- STRATEGY AND TECHNIQUES: KENNETH WRIGHT[16-18,24]

10. WADDENGHAM P.E. POSTOPERATIVE LEVELS OF STEREOACUITY FOLLOWING SURGICAL CORRECTION OF CONSTANT AND INTERMITTENT EXOTROPIA[27]

11. AAO: PEDIATRIC OPHTHALMOLOGY AND STRABISMUS[6,7]

12. OUTCOME OF UNILATERAL LATERAL RECTUS RECESSION AND MEDIAL RECTUS RESECTION IN PRIMARY EXOTROPIA: QURANTUL AIN SALEEM ET AL, BMC RESOURCE NOTES 2013[22].

13. ORBIS STUDY: INCIDENCE OF STEREOACUITY FOLLOWING CORRECTION OF LONG STANDING STRABISMUS AFTER 2 YRS OF AGE, ELIZABETH JOSEPH ET AL[14,21,28]

14. BINOCULARITY FOLLOWING SURGICAL CORRECTION OF STRABISMUS IN ADULTS, METS ET AL[23]

15. DUKE ELDER, SYSTEM OF OPHTHALMOLOGY VOL:6[9]

16. JACK KANSKI: TEXTBOOK OF OPHTHALMOLOGY[12,13]

PROFORMA

Name: Age: Sex: Roll no: IP No:

Duration of Deviation of Eyes:

Visual Acuity:

Orthoptics: Cover Test: PBCT: FR FL

Preoperative Binocular Single Vision Grade:

Worth Four Dot Test: Synoptophore: Titmus Fly Test:

Diagnosis:

Type of Surgery Done:

Post Op Follow Up **At 1 Week**:

Amount of Residual Deviation:

BSV Grading With WFDT: Synoptophore:

Titmus Fly Test:

At 2 Week:

Amount of Residual Deviation:

BSV Grading With WFDT: Synoptophore:

Titmus Fly Test:

At 1 Month:

Amount of Residual Deviation:

BSV Grading With WFDT: Synoptophore:

Titmus Fly Test:

At 3 Month:

Amount of Residual Deviation:

BSV Grading With WFDT: Synoptophore:

Titmus Fly Test:

no	name	e in y	sex	type of squint	degree of squint	type of surgery done	preop BSV	postop BSV grade	residual squint	stereoacuity
1	ramakrishna	12	m	RDS	40	R-R	absent	grade 1	0 degree	absent
2	rajendran	13	m	ACS	60	R-R	absent	absent	0 degree	absent
3	suganya	21	f	ACS	60	R-R	absent	absent	0 degree	absent
4	santhiya	9	f	RDS	50	R-R	absent	grade 2	5 degree	absent
5	narendran	5	m	RDS	40	R-R	grade 2	grade 3	0 degree	present
6	divya	7	f	LDS	50	R-R	grade 2	grade 3	0 degree	present
7	saravanan	4	m	ACS	40	Bimedial recession	absent	absent	5 degree	absent
8	naveen	14	m	ACS	30	R-R	absent	absent	0 degree	absent
9	jeshmitha	4	f	ACS	50	Bimedial recession	absent	absent	0 degree	absent
10	charulatha	26	f	ACS	30	R-R	absent	absent	10 degree	absent
11	sadhiya	12	f	ACS	30	R-R	absent	absent	5 degree	absent
12	divya	9	f	RDS	30	R-R	absent	grade 2	0 degree	absent
13	ajmal	16	m	RDS	50	R-R	absent	grade 1	0 degree	absent
14	xavier	22	m	LDS	50	R-R	absent	absent	0 degree	absent
15	rekha	14	f	ADS	50	R-R	absent	grade 1	0 degree	absent
16	banupriya	14	f	RDS	50	R-R	absent	grade 1	5 degree	absent
17	vijaykumar	9	m	LDS	45	R-R	absent	grade 1	0 degree	absent
18	perumal	25	m	RDS	30	R-R	absent	absent	0 degree	absent
19	peter	9	m	LDS	30	R-R	absent	grade 1	5 degree	absent
20	venkatraman	8	m	RDS	50	R-R	absent	grade 1	5 degree	absent
21	bhopal	30	m	LCS	50	R-R	absent	absent	5 degree	absent
22	rani	5	f	ACS	45	Bimedial recession	absent	absent	0 degree	absent
23	pooja	26	f	LCS	45	R-R	absent	absent	0 degree	absent
24	tarun	29	m	ACS	50	R-R	absent	absent	5 degree	absent
25	lakshmi	40	f	ACS	30	R-R	absent	absent	0 degree	absent
26	gomathy	8	f	ADS	20	R-R	absent	grade 1	0 degree	absent
27	maran	25	m	ACS	30	R-R	absent	absent	15 degree	absent
28	Gopika	7	f	LDS	50	R-R	grade 1	grade 3	0 degree	present
29	aswatha	4	f	ACS	70	Bimedial recession	absent	absent	10 degree	absent
30	leela	35	f	ACS	45	R-R	absent	absent	0 degree	absent
31	Ramannama	7	f	RDS	80	R-R	absent	grade 1	0 degree	absent
32	Prakash	27	m	ACS	40	R-R	absent	absent	20 degree	absent

33	Maha	22	f	ACS	50	R-R	absent	absent	0 degree	absent
34	ram	9	m	ADS	35	R-R	absent	grade 1	0 degree	absent
35	jemo	6	m	ACS	35	Bimedial recession	absent	absent	0 degree	absent
36	sivanesh	29	m	ADS	50	R-R	absent	absent	5 degree	absent
37	Varun	6	m	RDS	70	R-R	absent	present	5 degree	absent
38	priya	4	f	ACS	35	Bimedial recession	absent	absent	15 degree	absent
39	shiny	7	f	ADS	50	R-R	absent	grade 2	0 degree	absent
40	Fathima	27	f	ADS	25	R-R	absent	absent	0 degree	absent
41	dharshan	28	m	ADS	25	R-R	absent	absent	0 degree	absent
42	supriya	22	f	ADS	30	R-R	absent	absent	0 degree	absent
43	rajakumari	27	f	ACS	25	R-R	absent	absent	10 degree	absent
44	Latha	23	f	ADS	25	R-R	absent	absent	0 degree	absent
45	Padma	16	f	ADS	30	R-R	absent	absent	5 degree	absent
46	siva	9	m	ADS	40	R-R	absent	grade 2	0 degree	absent
47	Mani	34	m	ADS	20	R-R	absent	absent	0 degree	absent
48	ravi	13	m	ADS	15	R-R	absent	present	0 degree	absent
49	shalini	18	f	ADS	15	R-R	absent	absent	0 degree	absent
50	jhansi	32	f	ADS	90	R-R	absent	absent	20 degree	absent

KEY TO MASTER CHART

M – MALE

F – FEMALE

RCS – RIGHT CONVERGENT SQUINT

LCS- LEFT CONVERGENT SQUINT

ACS- ALTERNATING CONVERGENT SQUINT

RDS-RIGHT DIVERGENT SQUINT

LDS-LEFT DIVERGENT SQUINT

ADS-ALTERNATING DIVERGENT SQUINT

R-R -RECESSION-RESECTION SURGERY

ABBREVIATIONS

RE	:	RIGHT EYE
LE	:	LEFT EYE
NAD	:	NO ABNORMALITY DETECTED
FR	:	FIXING WITH RIGHT EYE
FL	:	FIXING WITH LEFT EYE
PD	:	PRISM DIOPTRES
FDT	:	FORCED DUCTION TEST
MR	:	MEDIAL RECTUS
LR	:	LATERAL RECTUS
BSV	:	BINOCULAR SINGLE VISION
EOM	:	EXTRA OCULAR MOVEMENT
SLE	:	SLIT LAMP EXAMINATION
PBCT	:	PRISM BAR COVER TEST
ADS	:	ALTERNATING DIVERGENT SQUINT
RCS	:	RIGHT CONVERGENT SQUINT
WFDT	:	WORTH FOUR DOT TEST

V/A	:	VISUAL ACUITY
SMP	:	SIMULTANEOUS MACULAR PERCEPTION
BO PRISM	:	BASE OUT PRISM
BI PRISM	:	BASE IN PRISM
BMR	:	BIMEDIAL RECESSION
R-R	:	RECESSION- RESECTION